Principles of
...lar Box Cooker Design

Mark Aalfs, Solar Box Cookers Northwest
523 18th Avenue East, Seattle, WA 98112, 206-328-0832

...urpose of this ...is to summarize the ...ic principles ...sed in the design ...r box cookers.

...eople use solar cookers ...marily to cook food and pasteurize water, although additional uses are continually being developed. But numerous factors including access to materials, availability of traditional cooking fuels, climate, food preferences, cultural factors, and technical capabilities, affect people's approach to solar cooking.

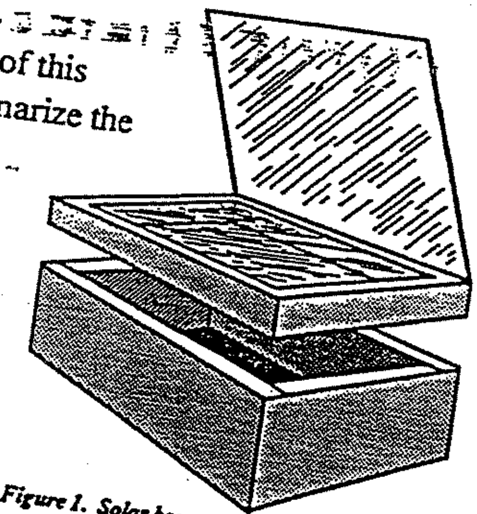


Figure 1. Solar box cooker with cover, window, and reflector

With an understanding of basic principles of solar energy and access to simple materials such as cardboard, aluminum foil, and glass, one can build an effective solar cooking device. This paper outlines the basic principles of solar box cooker design and identifies a broad range of potentially useful construction materials.

These principles are presented in general terms so that they are applicable to a wide variety of design problems. Whether the need is to cook food, pasteurize water, or dry fish or grain; the basic principles of solar, heat transfer, and materials apply. We look forward to the application of a wide variety of materials and techniques as people make direct use of the sun's energy.

The following are the general concepts relevant to the design or modification of a solar box cooker:

- Heat Principles
- Materials Requirements
- Design and Proportion
- Solar Box Cooker Operation
- Cultural Factors

HEAT PRINCIPLES

The basic purpose of a solar box cooker is to heat things up ...cook food, purify water, and sterilize instruments -- to ...ention a few.

A solar box cooks because the interior of the box is heated by the energy of the sun. Sunlight, both direct and reflected, enters the solar box through the glass or plastic top. It turns to heat energy when it is absorbed by the dark absorber plate and cooking pots. This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain. Temperatures sufficient for cooking food and pasteurizing water are easily achieved.

Given two boxes that have the same heat retention capabilities, the one that has more gain, from stronger sunlight or additional sunlight via a reflector, will be hotter inside.

Given two boxes that have equal heat gain, the one that has more heat retention capabilities — better insulated walls, bottom, and top — will reach a higher interior temperature.

The following heating principles will be considered first:

A. Heat gain
B. Heat loss
C. Heat storage

A. Heat gain

Greenhouse effect: This effect results in the heating of enclosed spaces into which the sun shines through a transparent material such as glass or plastic. Visible light easily passes through the glass and is absorbed and reflected by materials within the enclosed space.

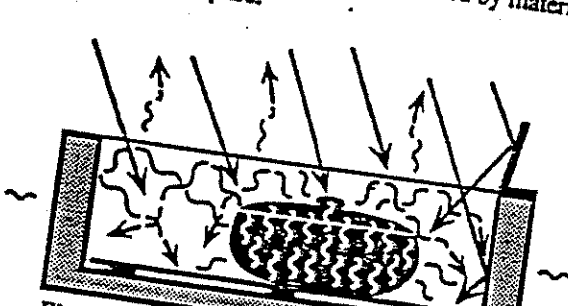


Figure 2. The greenhouse effect

The light energy that is absorbed by dark pots and the dark absorber plate underneath the pots is converted into longer wavelength *heat* energy and radiates from the interior materials. Most of this radiant energy, because it is of a longer wavelength, cannot pass back out through the glass and is therefore trapped within the enclosed space.

The reflected light is either absorbed by other materials within the space or, because it doesn't change wavelength, passes back out through the glass.

Critical to solar cooker performance, the heat that is collected by the dark metal absorber plate and pots is conducted through those materials to heat and cook the food.

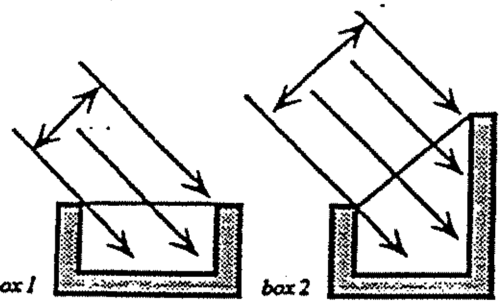


Figure 3. Glass orientation

Glass orientation: The more directly the glass faces the sun, the greater the solar heat gain. Although the glass is the same size on *box 1* and *box 2*, more sun shines through the glass on *box 2* because it faces the sun more directly. Note that *box 2* also has more wall area through which to lose heat.

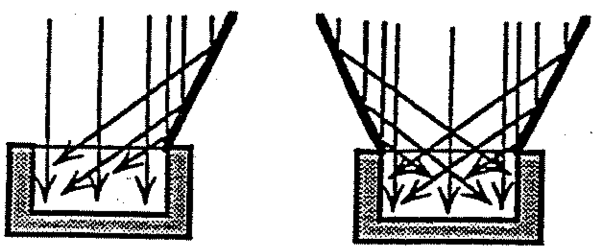


Figure 4. Reflectors for additional gain

Reflectors, additional gain: Single or multiple reflectors bounce additional sunlight through the glass and into the solar box. This additional input of solar energy results in higher cooker temperatures.

B. Heat loss

The Second Law of Thermodynamics states that heat always travels from hot to cold. Heat within a solar box cooker is lost in three fundamental ways:

Conduction
Radiation
Convection

Conduction: The handle of a metal pan on a stove or fire becomes hot through the transfer of heat from the fire through the materials of the pan, to the materials of the handle. In the same way, heat within a solar box is lost when it travels through the molecules of tin foil, glass, cardboard, air, and insulation, to the air outside of the box.

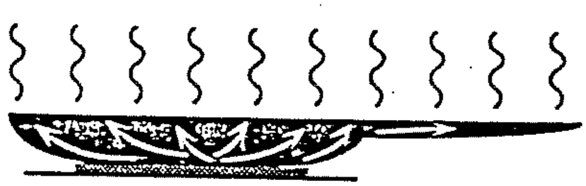


Figure 5. Heat conducted through the pan to handle

The solar heated absorber plate *conducts* heat to the bottoms of the pots. To prevent loss of this heat via conduction through the bottom of the cooker, the absorber plate is raised from the bottom using small insulating spacers as in *figure 6.*

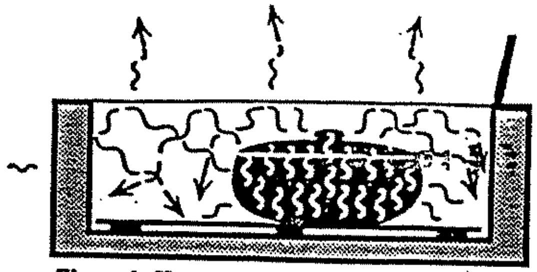


Figure 6. Heat radiates from warm cookware.

Radiation : Things that are warm or hot -- fires, stoves, or pots and food within a solar box cooker -- give off heat waves, or radiate heat to their surroundings. These heat waves are radiated from warm objects through air or space. Most of the radiant heat given off by the warm pots within a solar box is reflected from the foil and glass back to the pots and bottom tray. Although the transparent glazings do trap most of the radiant heat, some does escape directly through the glazing. Glass traps radiant heat better than most plastics.

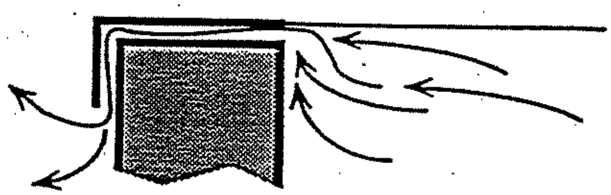


Figure 7. Heated air may escape through cracks.

Convection: Molecules of air move in and out of the box through cracks. They convect. Heated air molecules within a solar box escape, primarily through the cracks around the top lid, a side "oven door" opening, or construction imperfections. Cooler air from outside the box also enters through these openings.

C. Heat storage:

As the density and weight of the materials within the insulated shell of a solar box cooker increase, the capacity of the box to hold heat increases. The interior of a box including heavy materials such as rocks, bricks, heavy pans, water, or heavy foods will take longer to heat up because of this additional heat storage capacity. The incoming energy is stored as heat in these heavy materials, slowing down the heating of the air in the box.

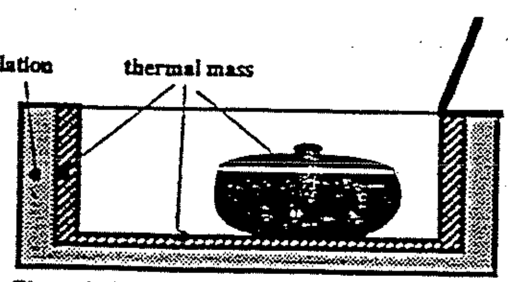


Figure 8. Thermal mass inside of the solar box.

These dense materials, charged with heat, will radiate that heat within the box, keeping it warm for a longer period at the day's end.

MATERIALS REQUIREMENTS

There are three types of materials that are typically used in the construction of solar box cookers. A property that must be considered in the selection of materials is moisture resistance.

- **A. Structural material**
- **B. Insulation**
- **C. Transparent material**
- **D. Moisture resistance**

A. Structural material

Structural materials are necessary so that the box will have and retain a given shape and form, and be durable over time.

Structural materials include cardboard, wood, plywood, masonite, bamboo, metal, cement, bricks, stone, glass, fiberglass, woven reeds, rattan, plastic, papier mache, clay, rammed earth, metals, tree bark, cloth stiffened with glue or other material.

Many materials that perform well structurally are too dense to be good insulators. To provide both structural integrity and good insulation qualities, it is usually necessary to use separate structural and insulating materials.

B. Insulation

In order for the box to reach interior temperatures high enough for cooking, the walls and the bottom of the box must have good insulation (heat retention) value. Good insulating materials include: aluminum foil (radiant reflector), feathers (down feathers are best), spun fiberglass, rockwool, cellulose, rice hulls, wool, straw, and crumpled newspaper.[1]

When building a solar cooker, it is important that the insulation materials surround the interior cooking cavity of the solar box on all sides except for the glazed side -- usually the top. Insulating materials should be installed so that they allow minimal conduction of heat from the inner box structural materials to the outer box structural materials. The lower the box heat loss, the higher the cooking temperatures.

C. Transparent material

At least one surface of the box must be transparent and face the sun to provide for heating via the "greenhouse effect." The most common glazing materials are glass and high temperature plastics such as oven roasting bags. Double glazing using either glass or plastic affects both the heat gain and the heat loss. Depending on the material used, the solar transmittance -- heat gain -- may be reduced by 5-15%. However, because the heat loss through the glass or plastic is cut in half, the overall solar box performance is increased.

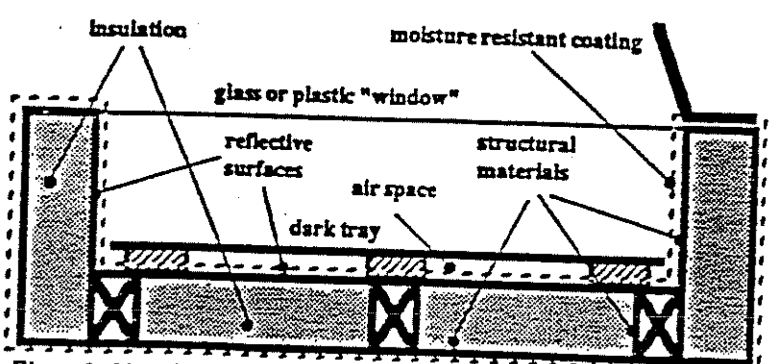


Figure 9: Materials: structural, insulation, transparent, and moisture resistant.

D. Moisture resistance

Most foods that are cooked in a solar box cooker contain moisture. When water or food is heated in the solar box, a vapor pressure is created, driving the moisture from the inside to the outside of the box. There are several ways that this moisture can travel. It can escape directly through box gaps and cracks or be forced into the box walls and bottom if there is no moisture barrier. If a box is designed with high quality seals and moisture barriers, the water vapor may be retained inside the cooking chamber. In the design of most solar box cookers, it is important that the inner-most surface of the cooker be a good vapor barrier. This barrier will prevent water damage to the insulation and structural materials of the cooker by slowing the migration of water vapor into the walls and bottom of the cooker.

DESIGN AND PROPORTION

A. Box size

A solar box cooker should be sized in consideration of the following factors:

- The size should allow for the largest amount of food commonly cooked.
- If the box needs to be moved often, it should not be so large that this task is difficult.
- The box design must accommodate the cookware that is available or commonly used.

B. Solar collection area to box volume ratio

Everything else being equal, the greater the solar collection area of the box relative to the heat loss area of the box, the higher the cooking temperatures will be.

Given two boxes that have solar collection areas of equal size and proportion, the one that is of less depth will be hotter because it has less heat loss area.

C. Solar box cooker proportion

A solar box cooker facing the noon sun should be longer in the east/west dimension to make better use of the reflector over a cooking period of several hours. As the sun travels across the sky, this configuration results in a more consistent cooking temperature. With square cookers or ones having the longest dimension north/south, a greater percentage of the early morning and late afternoon sunlight is reflected from the reflector to the ground, missing the box collection area.

D. Reflector

One or more reflectors are employed to bounce additional light into the solar box in order to increase cooking temperatures. This component is optional in equatorial climates but increases cooking performance in temperate regions of the world. See Figure 4 on page 2.

SOLAR BOX COOKER OPERATION

One of the beauties of solar box cookers is their ease of operation. For mid-day cooking at 20° N - 20° S latitude, solar box cookers with no reflector need little repositioning to face the sun as it moves across the mid-day sky. The box faces up and the sun is high in the sky for a good part of the day. Boxes with reflectors can be positioned toward the morning or afternoon sun to do the cooking at those times of day.

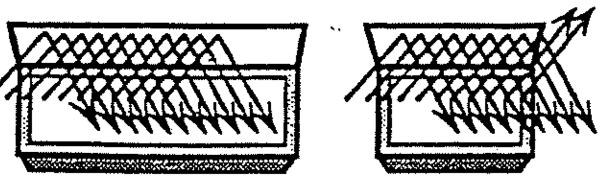


***Figure 10:** Wider solar boxes catch more of the east and west sunlight.*

Solar box cookers used with reflectors in the temperate zones do operate at higher temperatures if the box is repositioned to face the sun every hour or two. This adjustment of position becomes less necessary as the east/west dimension of the box increases relative to the north/south dimension.

CULTURAL FACTORS

In addition to the primarily technical aspects of solar box cooker design, factors including culture, appropriate technology, and aesthetics play a major role in the successful technology transfer of solar box cooking.

Through the centuries, the power of the sun has been tapped in numerous ways. With solar cooking, as with other endeavors, some design approaches work better than others. Technology that is designed to efficiently accomplish a given task while meeting certain energy use, environmental, social, cultural, and/or aesthetic standards, is often referred to as "appropriate technology."

Unfortunately, the field of solar cooking has its share of devices that fail these basic technical and social tests. For example, parabolic cookers can cook food, but when compared to the solar box approach, they are more difficult to build, require specialized materials and constant refocusing, may burn food, and are not likely to be accepted in most social and cultural contexts. In fact, because of the well publicized failures of these devices in several development projects in the '60s, many still believe that solar cooking is not feasible.

The better a given solar box design meets appropriate technology criteria, the more likely it is to be embraced by those using it. A very low-tech approach is to simply dig a shallow pit in the ground, insulate the bottom with dried grass or leaves, insert the food or water in a dark container, and place glass over the top. On the high-tech end of the scale, the very same solar principles could be used with standard building and insulating materials and high performance low-emmissivity glazing, to architecturally integrate a solar cooker into the south side of a contemporary kitchen. The solar oven door could be on the wall at a convenient height right next to the microwave.

Cardboard solar box cookers may be appropriate for many cultures because the materials are widely available and inexpensive. But disadvantages of cardboard include susceptibility to moisture damage and lack of durability compared to many other materials.

Aesthetics are usually important. Cultures having rounded forms as the norm may reject the entire solar cooking concept because the box is square. And certain social strata may reject cardboard as too "cheap" a material for their use.

It is important that the basic principles of solar design not be rejected because of the failures of a particular solar devices or technology transfer methodologies!

Certainly, one of the advantages of people designing their own solar box cookers is that they will apply the solar principles using their own materials and aesthetic sense. People that build their houses and furnishings out of wood or bamboo, are likely to include these materials in their cooker design. Surface decoration of solar boxes using various paints and textures also helps to integrate cookers into a given culture. There are many *forms* that can follow the solar *function*.

Location of the solar cooker and the cooking activity, permanence or portability of the solar cooker, time of day when it is used, and importance of cooking as a social activity are other varying factors that will affect the design of solar cookers.

The solar box cooker project in the Indian Himalaya, sponsored by the Indo-German Dhauladhar Project, is a successful application of the principles of solar box cooking to the needs of a particular culture. The non portable cooker is built of earth and brick and is double glazed with glass. An inner tin oven is fabricated from used ghee or oil containers. Husk from a rice sheller provides insulation around the tin oven.

> "Materials are derived from the market economy (glass, black paint, nails, etc.), the local economy (labor, wood), and the non-monetary subsistence economy (mud bricks, bamboo, fabric). Using familiar materials and skills makes it easy to train builders and to help people maintain their cookers."[2]

The Dhauladhar Project participants, through the adaptation of solar cooking concepts to local needs and customs, demonstrated an effective technology transfer process.

Although it is somewhat beyond the scope of this discussion of design principles, other factors critical to the successful long-term implementation of solar cooking deserve note.

In order to successfully transfer solar cooking technology from one culture to another, a durable and long-lived bridge is critical. Individuals from both cultures form that bridge. People from the transferring culture must have a high degree of cultural sensitivity and make a significant time commitment. Success is more likely if individuals from the implementing culture are leaders in their own communities. How well these individuals work together will play a large part in the success or failure of the process. Community is, by definition, a web of interconnected activities. For solar cooking to become a part of local culture, it must be considered in the context of community activities such as local economics, work, healthcare, social activities, energy resources, deforestation, education, the technical infrastructure, and others.

Solar box cooking has already been practiced within a variety of cultures. But we've only scratched the surface. The potentially dramatic benefit of this resource in terms of world hunger, health, and deforestation has yet to be realized.

One of the primary purposes of Solar Box Cookers Northwest is to further the cause of solar cooking worldwide through information distribution and technology transfer. If you would like to work with us, we'd be happy to discuss our work and any of your ideas. We also like to see new designs and photos. Please contact us at the address on the first page of this paper.

1. Pejack, Ed. *"Insulation Materials For Solar Box Cookers,"* Sunworld, International Solar Energy Society, March 1990, p. 18.
2. Farwell, Eddie. *"Didi Contractor's Solar Cookers in the Indian Himalaya,"* 1345 Masonic Avenue, San Francisco, CA 94117

The "Easy Lid" Cooker

Although designs for cardboard cookers have gotten simpler, fitting a lid can still be difficult and time consuming. In this version, a lid is formed automatically from the outer box.

Making the Base

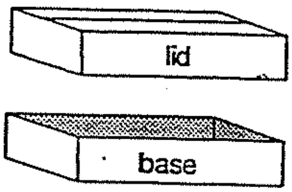


Figure 1

1. Take a large box and cut it in half as shown in Figure 1. Set one half aside to be used for the lid. The other half becomes the base.

2. Fold an extra cardboard piece so that it forms a liner around the inside of the base (see Figure 2).

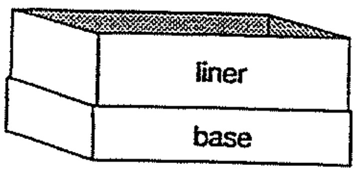


Figure 2

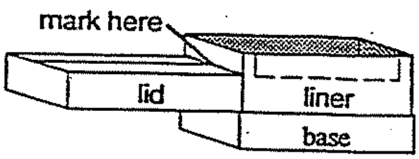


Figure 3

3. Use the lid piece as shown in Figure 3 to mark a line around the liner.

4. Cut along this line, leaving the four tabs as shown in Figure 4.

5. Glue aluminum foil to the inside of the liner and to the bottom of the outer box inside.

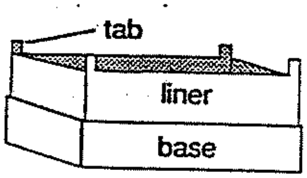


Figure 4

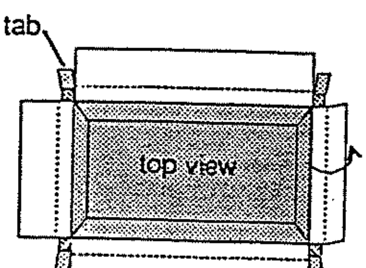


Figure 5

6. Set a smaller (inner) box into the opening formed by the liner until the flaps of the smaller box are horizontal and flush with the top of the liner (see Figure 5). Place some wads of newspaper between the two boxes for support.

7. Mark the underside of the flaps of the smaller box using the liner as a guide.

8. Fold these flaps down to fit down around the top of the liner and tuck them into the space between the base and the liner (see Figure 6).

9. Fold the tabs over and tuck them under the flaps of the inner box so that they obstruct the holes in the four corners (see Figure 6).

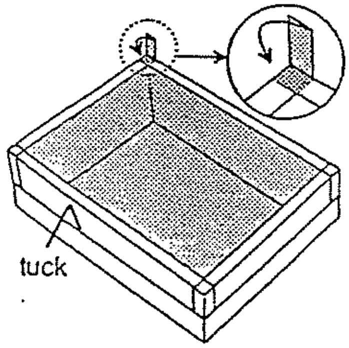


Figure 6

10. Now glue these pieces together in their present configuration.

11. As the glue is drying, line the inside of the inner box with aluminum foil.

Finishing the Lid

1. Measure the width of the walls of the base and use these measurements to calculate where to make the cuts that form the reflector in Figure 8. Only cut on three sides. The reflector is folded up using the fourth side as a hinge.

2. Glue plastic or glass in place on the underside of the lid. If you are using glass, sandwich the glass using extra strips of cardboard. Allow to dry.

3. Bend the ends of the wire as shown in Figure 7 and insert these into the corrugations on the lid and on the reflector to prop open the latter.

4. Paint the sheet metal (or cardboard) piece black and place it into the inside of the oven.

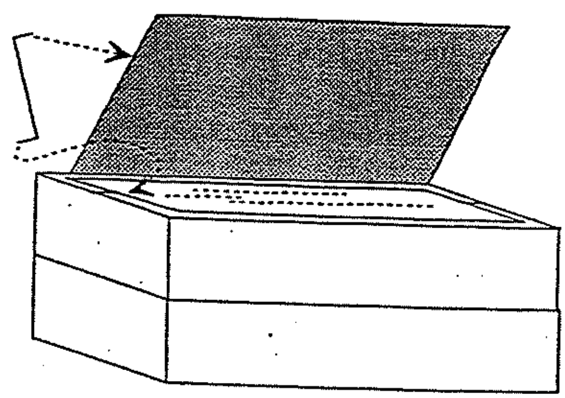


Figure 7

Improving Efficiency

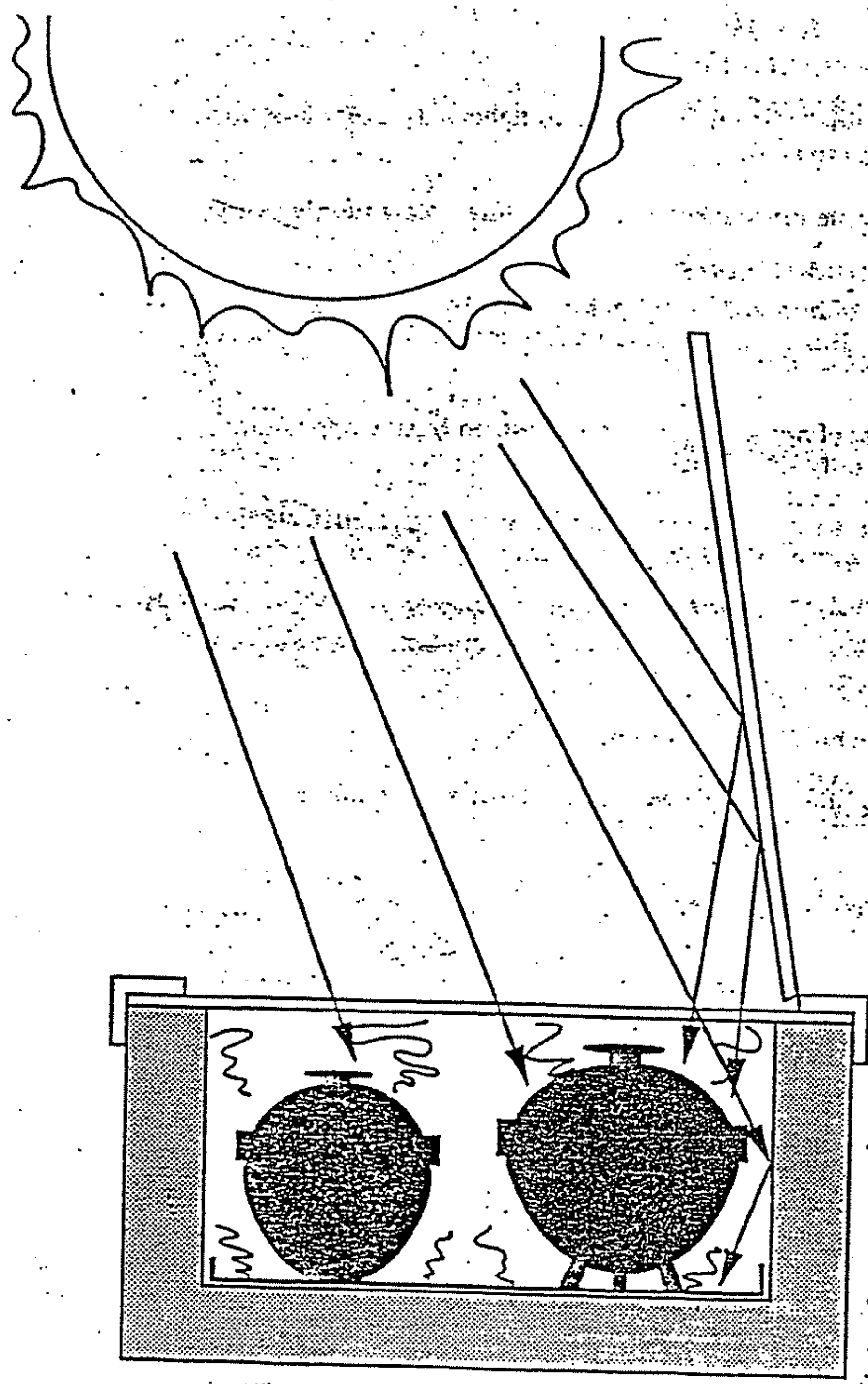
1. Glue thin strips of cardboard underneath the sheet metal (or cardboard) piece to elevate it off of the bottom of the oven slightly.

2. Cut off the reflector and replace it with one that is as large as (or larger than) the entire lid. This reflects light into the oven more reliably.

3. Turn the oven over and open the bottom flaps. Place one foiled cardboard panel into each airspace to divide each into two spaces. The foiled side should face the center of the oven.

Design by Chau Tan and Tom Sponheim

HOW DOES A SOLAR BOX COOKER WORK?



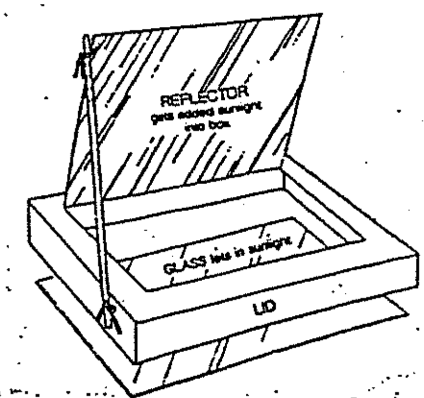
Dark, covered pots and dark tray turn sunlight into heat

A reflector held by a prop catches extra sunlight

A clear window lets in sunlight and holds in heat

A double-walled insulated box holds in heat to cook food

TEN STEPS TO BUILD A SOLAR BOX COOKER



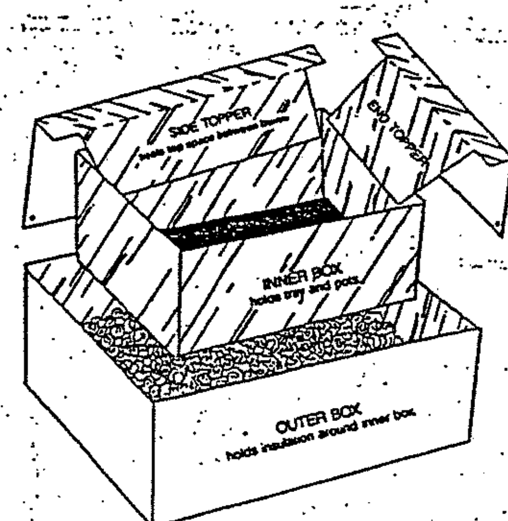
This cooker is made from cardboard, glass, aluminum foil and glue, a stick and string. For making a cooker from other materials see p. 10, More Detail.

1. GATHER MATERIALS:

GLASS - ordinary (untempered) window glass about 50x60 cm (20x24 inches).

CARDBOARD - about 4 square meters/60 square feet, and a knife to cut it

- For two large boxes and a lid. Finished size:
  - Lid: 61x71x8 cm(24x28x3 inches)
  - Inner box: 46x56x20 cm (19x23x8")
  - Outer box: a little longer, wider and taller - 56x66x25cm (23x27x9")
- BOTTOM SUPPORTS - small scraps glued to make six stacks 3 cm (1 in.) tall
- 4 INSULATOR PIECES like the walls of the bigger box to fit between boxes-(optional-see variations)
- 4 "TOPPERS" - if boxes don't have flaps (see p.6)

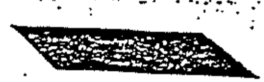


ALUMINUM FOIL - 20x.3 meters (60x1 feet)

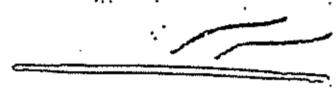
SILICONE CAULK to glue window to lid and/or

WATER-BASE GLUE - 1 liter (quart). For 1) lid corners, 2) to glue window in lid if you don't have silicone caulk and (3) dilute 1:1 with water to glue foil on boxes.

DARK, COOKING POTS WITH DARK LIDS and **BLACK METAL OR ALUMINUM FOIL TRAY** - to fit inside the inner box - 44x54cm (18x22").



PROP STICK - 70 cm (2 foot) length of stick and string. See p. for other types of props.

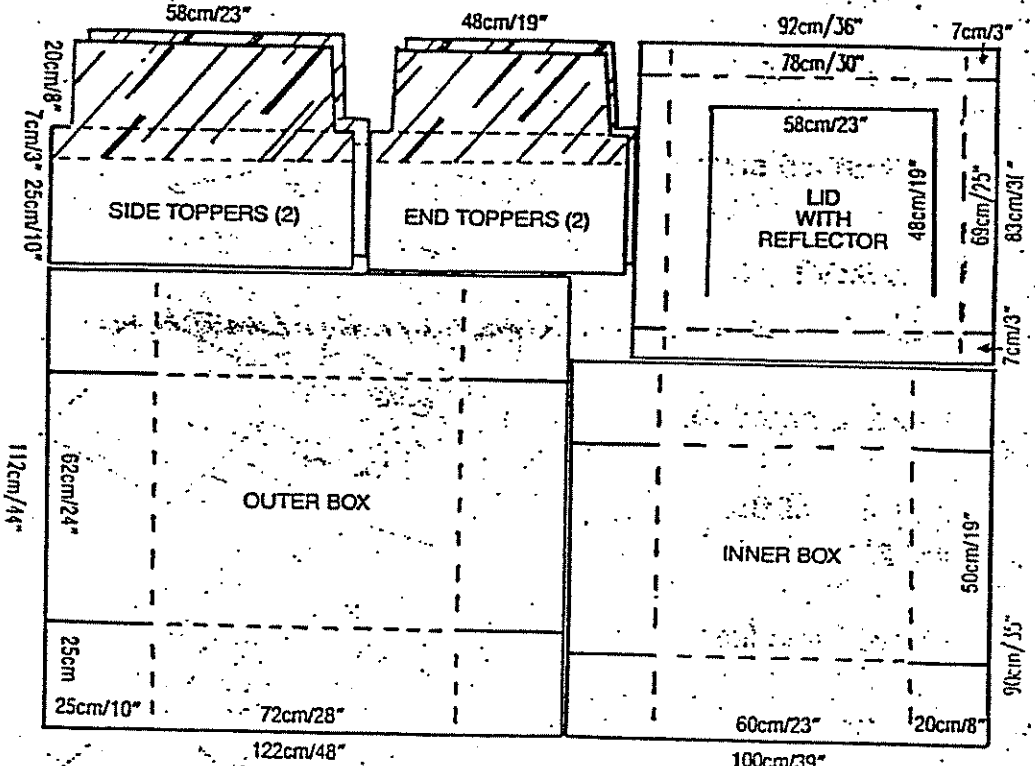


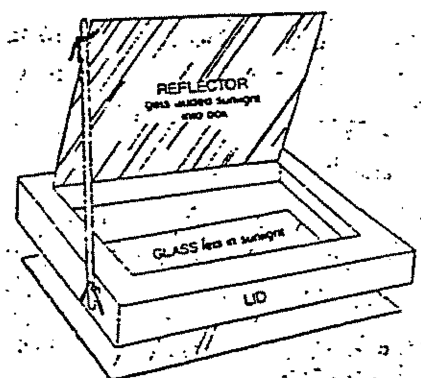
2. CUT CARDBOARD FOR TWO BOXES.

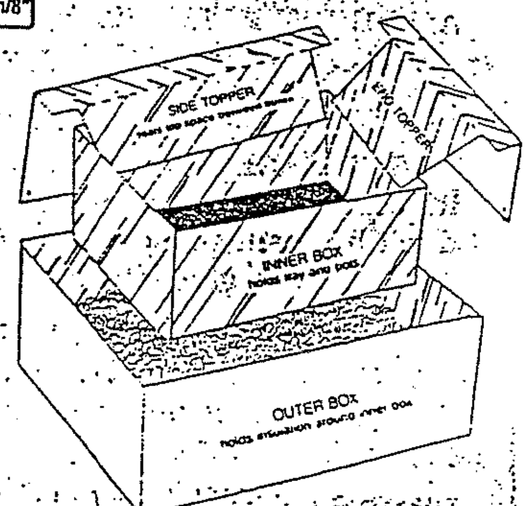
To make clean straight folds in cardboard, press first with a blunt edge such as a spoon handle, then fold against a firm straight edge.

A. STARTING WITH FLAT CARDBOARD: If you don't have big pieces, glue together small ones overlapping slightly.

Pattern for cardboard pieces 1/20 scale



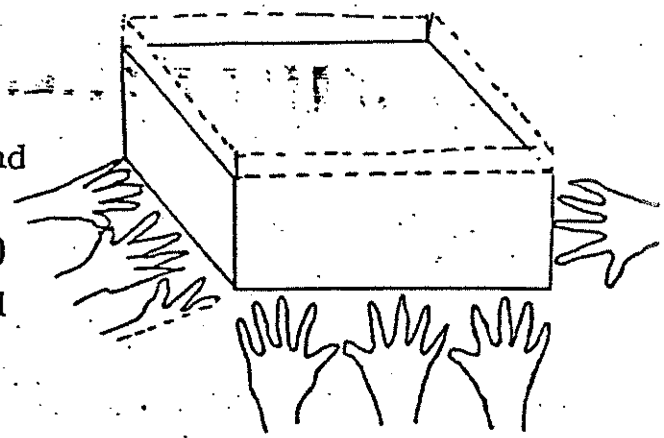




✻ "STANDARD" MODEL - this is the "original" SBCI cooker. Many thousands of these cookers have been built.

✻ NEW "STRIP" MODEL (see inside back cover) Go to p. 7.

2. CUT CARDBOARD FOR BOXES (cont.)



B. FROM BIG, READY-MADE BOXES:

Look for about these sizes: sometimes found at appliance stores .

Ideal inner box: 46x56x20 cm (19x23x8")

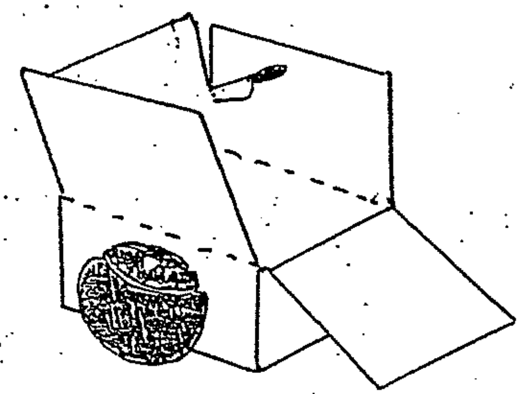
Ideal outer box: a little longer, wider and taller - 56x66x25cm (23x27x9")

Ideal space between boxes: 3 cm/1"

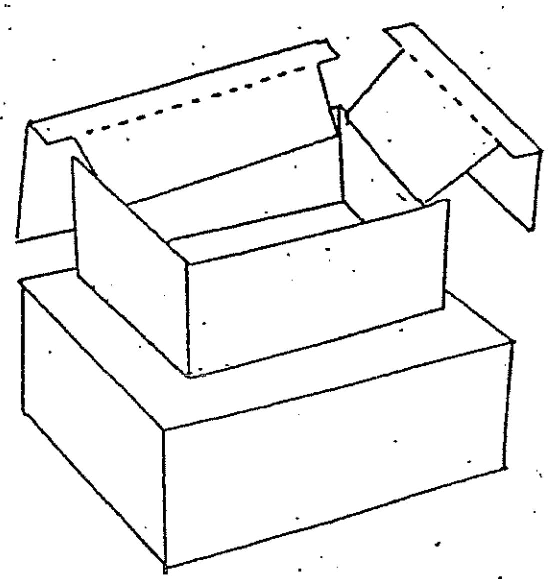
Lid: 61x71x8 cm(24x28x3 inches)

Adjust height of boxes:

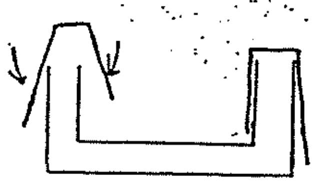
FOLD DOWN (don't cut off) the walls of the inner box to about 20 cm/8 inches tall, and the outer box to 25 cm/9 in. Be sure your covered pots will fit inside without touching the window.



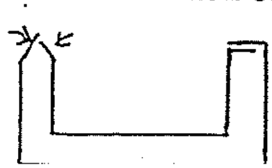
Pick one of the following ways to seal the space between the boxes. DON'T GLUE YET.

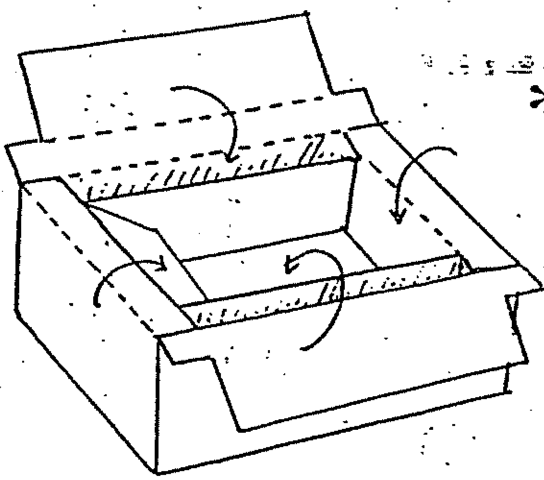


* OPTION #1 WITH TOPPERS when both boxes have no flaps: Cut 4 separate T-shaped "toppers" - (see p. 4).



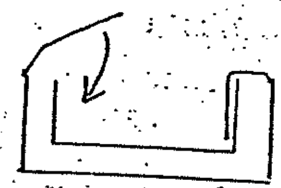
* OPTION #2 WITH SMALL FLAPS on both boxes like "Strip" model (see inside back cover)

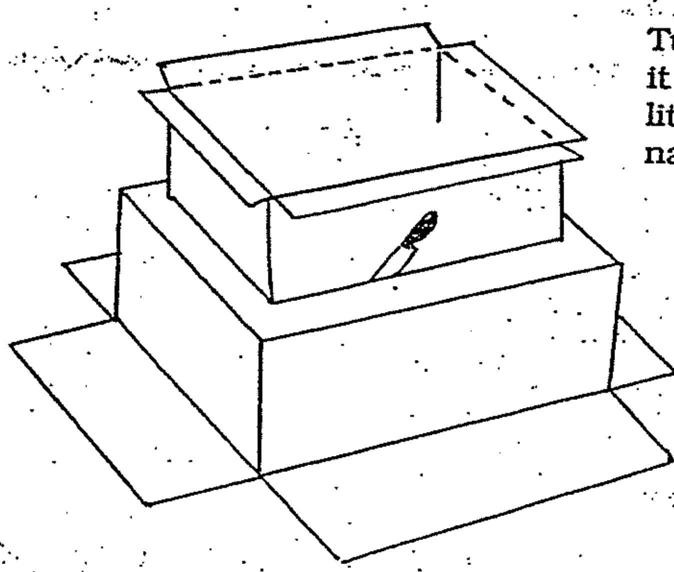




2. CUT CARDBOARD FOR BOXES Ways to seal (cont.)

* OPTION #3 If outer box has big flaps for toppers

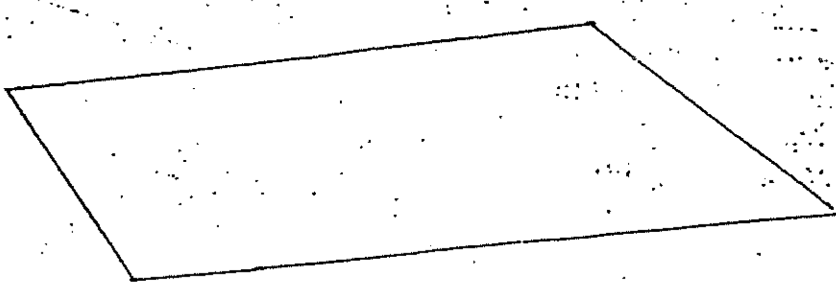




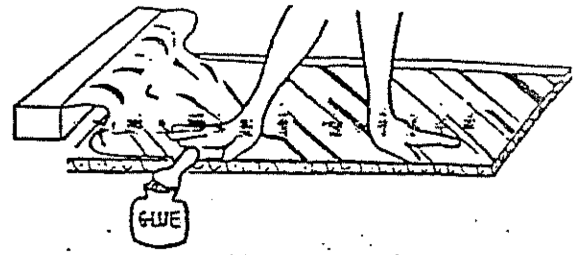
* OPTION #4 If inner box has small flaps and outer has big flaps you can make a QUICK UPSIDE-DOWN COOKER:

Turn the big box over, center the little box on it and trace around. Cut out this piece so little box drops in. Trim little box flaps as narrow as the rim left on the big box.

FOR THE LID: a large flat piece 15 cm/6" longer and wider than the outer box.

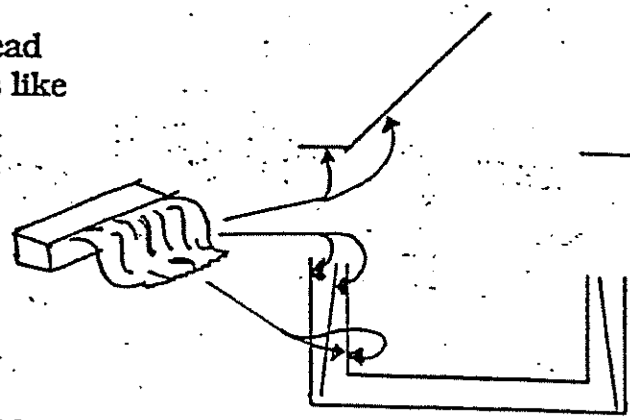


3. GLUE ALUMINUM FOIL to: (see also diagrams, p. 4)

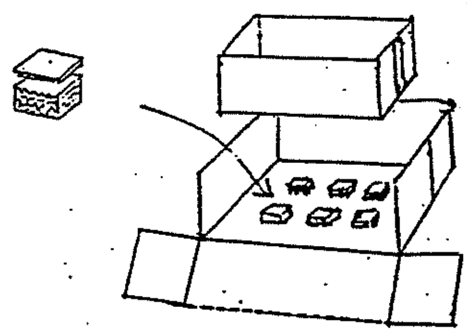


- BOTH sides of little box
- the inside of the bigger box and lid, * one side of insulator pieces
- flaps or toppers, if any, that will be inside the inner box

Add water to glue half-and-half, and spread all over THINLY and press foil so it sticks like wallpaper. Don't worry about a few air bubbles or wrinkles.



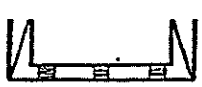
If you started with flat cardboard, now fold up and glue box sides to MAKE BOXES.



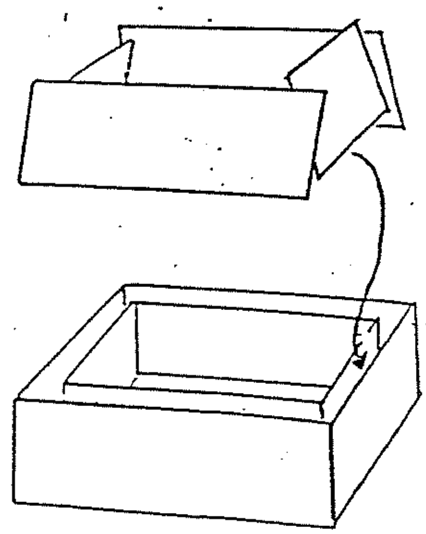
4. ADD BOTTOM SUPPORTS.

Glue six little stacks of cardboard 2-3 cm high (1") to support inner box.

Tape or glue supports to the underside of the inner box or to the inside bottom of the outer box.



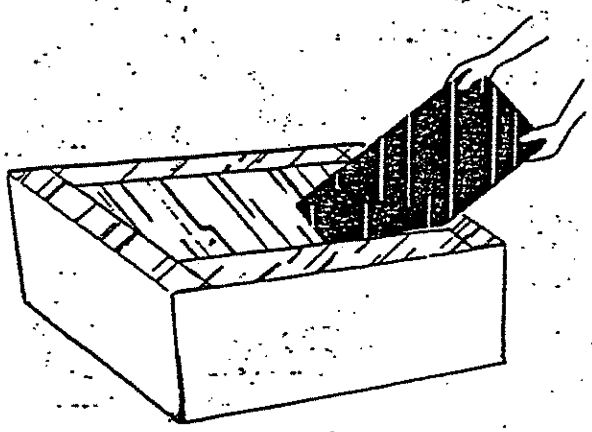
5. With one box inside the other ADD INSULATION.



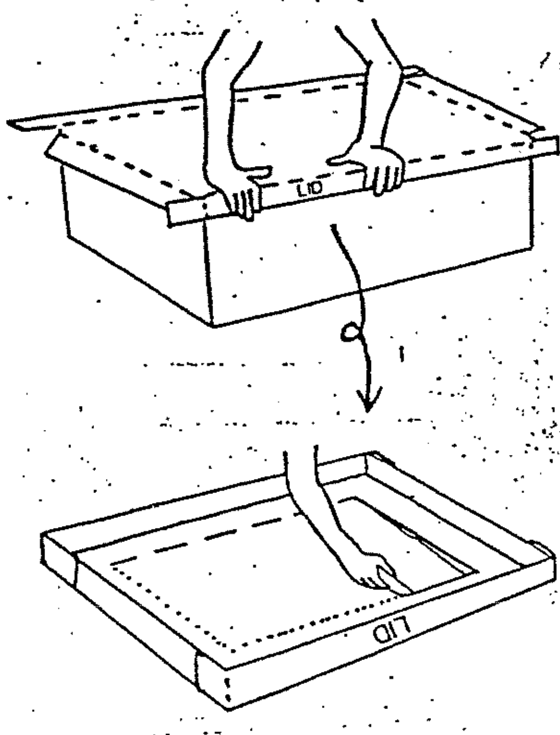
If you have extra cardboard and foil, make insulator pieces the size of the outer box walls and foil on one side to place between the walls. If not see p. 10 for other insulations.

6. SEAL SPACE BETWEEN THE BOXES

Glue toppers or flaps see p. 5-6. Glue cardboard patches over any holes in the boxes.



7. ADD BLACK TRAY inside inner box.



8. MAKE A LID

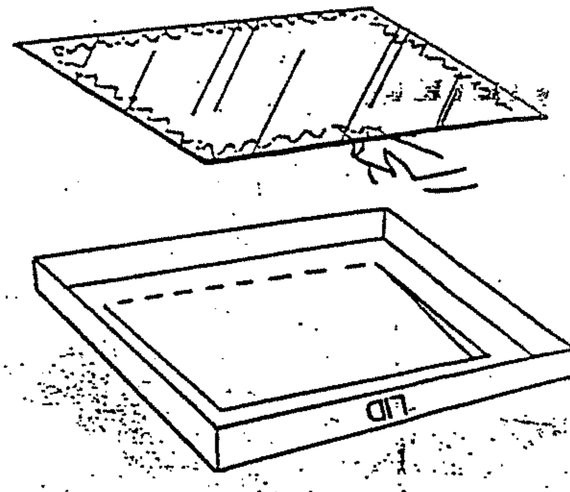
Center the flat lid piece on the box, foiled side down. Fold edges over the finished box for a good fit. Cut and fold the corner flaps and glue.

9. MAKE WINDOW AND REFLECTOR:

Draw a window opening in the center of the lid the size of the inner box (and a little smaller than the window piece). Cut three sides, leaving one long side to fold up for a reflector. The hole in the lid will be the window frame.

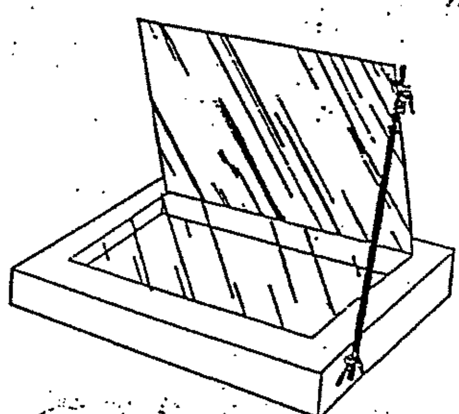
9. WINDOW AND REFLECTOR (cont.)

Spread caulk or glue along the edge of the window and press it against the inside edge of the window frame to make a good seal. Press flat with something heavy until dry.



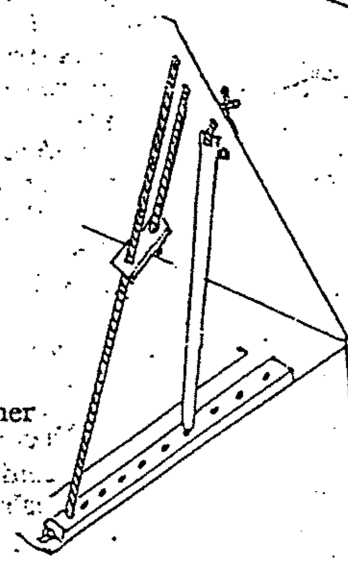
10. MAKE A PROP

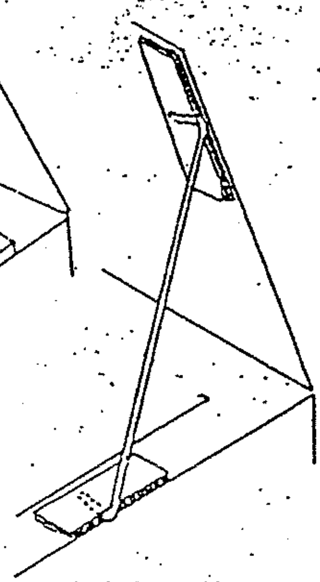
Attach a notched stick with string to the corner of the reflector and one side of the lid. In windy areas you may need a prop on both ends of the reflector.



Notched stick and string
to hold it firm at both ends.

VARIATIONS:
Sturdy stick and string prop for windy weather



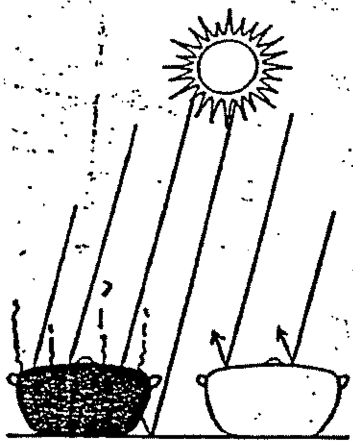


Wire and cardboard strips

After all the glue dries put the empty solar box in the sun for several hours to drive out the last bit of moisture from the box itself.

NOW YOU ARE READY TO COOK.

DETAILS AND VARIATIONS

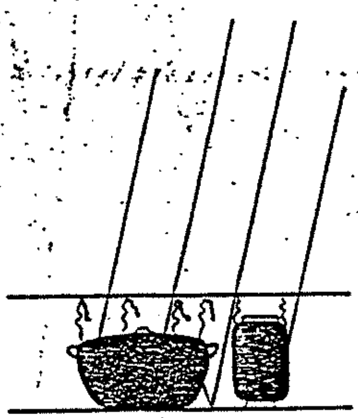


DARK COVERED POTS on a DARK TRAY

- **Best materials:** thin metal pots or glass jars painted black on the outside and black metal tray are best. Paint with flat black latex paint, blackboard paint or water-based glue mixed with black poster paint or soot. Smoke-colored glass pots and dark pots with glass lids are OK.

NOT GOOD: Oil-based paints - they give off fumes. Heavy pots/tray - especially ceramic - absorb heat so foods take longer to cook. However, heavy pots keep food hot longer if you eat after sunset.

- **Extra hint:** If you paint glass jars, leave a clear strip to see the food cooking inside.



CLEAR WINDOW

- Best size is about 60 x 50 cm (24 x 20 inches) to gather enough sunlight for cooking a family meal. Before framing it needs to be a little bigger than the inner box. A bigger window and box catches more energy to cook but is harder to handle; a smaller window/box may not cook well.

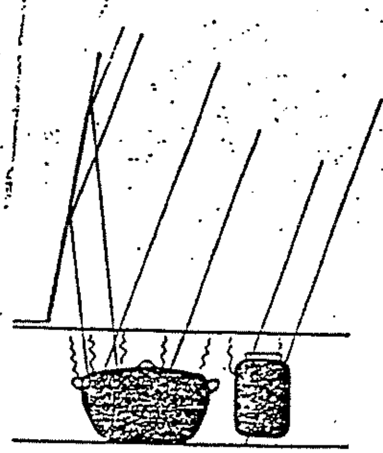
If window material is scarce, adjust box size to fit your window.

- Window material must be moisture-proof, be stiff in windy areas, and not melt or give off fumes at high temperatures.

A single layer of ordinary window glass works well (its frame must allow glass to expand with heat). Two layers of window with a thin air space between (1-2 cm, 1/4-1/2 inches) are better for cold or windy areas. Separate layers with cardboard strips around edges.

Other materials: An old car window or other tempered glass IF it isn't tinted to keep out sunlight; a large oven roasting bag or other high temperature plastics.

NOT GOOD: Most plastics melt or give off fumes so should only be used for the outer layer of a double window.



LID WITH REFLECTOR AND PROP

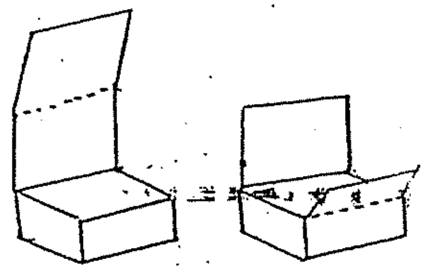
- The lid should fit tightly to hold in heat. For lid materials see Boxes.
- The shiny reflector along one long side of the lid adjusts up and down and the prop holds it where you want it.

The reflector surface can be anything shiny such as aluminum foil; the next best is a shiny white surface.

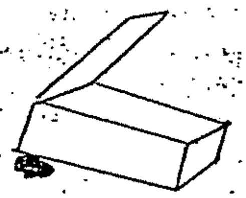
Variations:

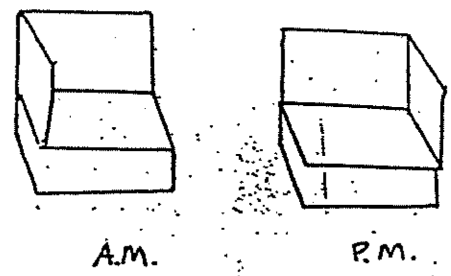
Some prefer gluing a larger, separate reflector piece to capture more sun and also to protect the window when closed.

Single versus multiple reflectors: A single reflector is simplest, doesn't require moving the cooker to follow the sun, and is usually most stable in the wind.
In areas far from the equator: some people prefer two or more reflectors. Here are some types which still allow "absentee" cooking:



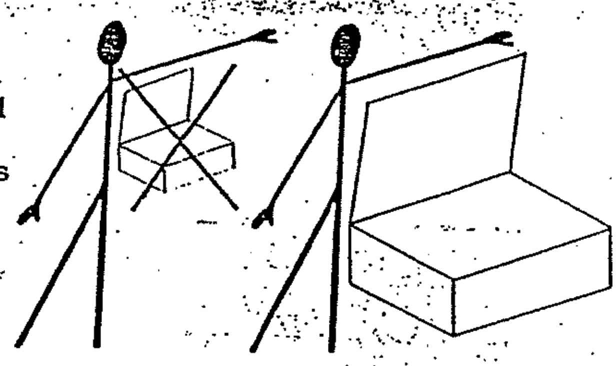
Also, people sometimes tip the cooker with a few rocks under the back of the cooker or build it with slanted top to catch the sun and for rain runoff.



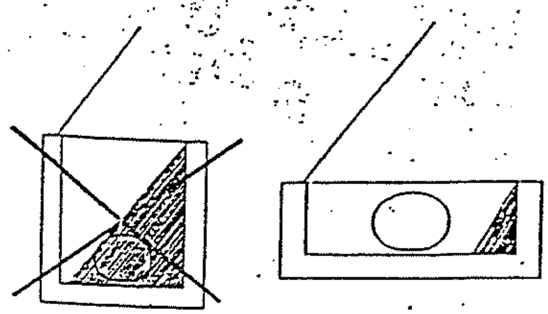


BOXES WITH INSULATION BETWEEN THEM

• Width and length of inner box should let in 2-3 square feet of sunshine - at least 45 x 55 cm (18x22 inches). Bigger is better, smaller holds fewer pots and may not cook as well. The outer box is just a little bigger to allow air space between them. Rectangular is better than square.



Inner box is as shallow as possible and less than half the box width, but slightly taller than your cooking pots so they don't touch the window. The fewer shadows on the pots and tray, the better food cooks. To cook with bigger, taller pots make the whole cooker bigger. The inner box needs thin, shiny walls to reflect light/heat to pots and bottom tray. Black walls capture more energy on overcast days and may increase air temperatures, but more heat escapes through the side walls instead of getting to food pots.

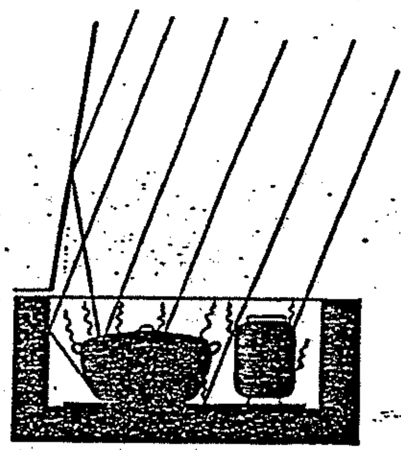


• Inner box materials must be moisture-proof so steam from food won't get into walls and drain off heat, also not melt or give off fumes at temperatures up to 150°C (300°F).

GOOD inner box materials: Corrugated cardboard is light-weight and helps insulate the cooker, stands high heat, and can be cut with a knife. When foiled it is shiny and also protected from moisture; be sure it wasn't used to store toxic chemicals. Other good materials: thin metal; thin wood, masonite or baskets with foil lining.

NOT GOOD: Plastics and styrofoam, which may melt or give off fumes

Heavy metal, adobe or bricks, which soak up heat.



Outer box materials: Just about anything.

Corrugated cardboard is light-weight and easy to work with. Cardboard can last many years, if protected on the outside with paint, wax, oil, or contact paper.

Metal - must not directly touch inner box or it will drain off heat

Wood, masonite, bamboo, wood bark

Plastic, fiberglass

Papier mache,

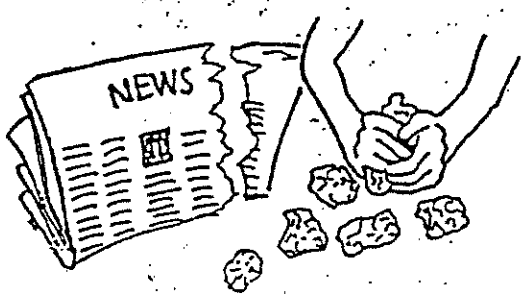
Baskets

Bricks, adobe

A hole in the ground (with good drainage).

Some people like a heavy, permanent cooker frame - sometimes built into a waist-high counter, others prefer a lightweight, portable one. It may need protection from rain, dew and ground moisture. A cooker must be dry to work well.

A cooker that opens on a side instead of the top is handier, but harder to build.



INSULATION between the walls of the two boxes

- the ideal space is 3 cm/1".

• Insulation materials must stay dry and not melt or give off fumes at high temperatures. Suggestions (from most to least effective): feathers, wool, 1+ wall-sized cardboard pieces covered with foil, crumpled newspaper - about 80 sheets quartered and crumpled into lemon-sized balls, dry plant fibers - rice hulls, straw, walnut or peanut (groundnut) shells, coconut fibers, dried banana leaves.

NOT GOOD: styrofoam pellets or other plastics next to the inner box.

GLUE: about 1 liter/quart

Best for gluing window to lid is silicone caulk; water-base glue is OK.

Best for gluing boxes together foil to cardboard is water-base glue: also flour paste, papier mache, acacia tree gum.

NOT GOOD: Most tapes don't last long. Petroleum- or rubber-based glues give off fumes and don't last long at high temperatures.

USING A SOLAR BOX

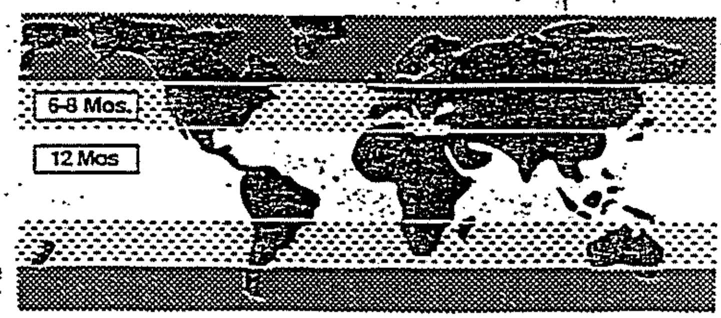
COMMON QUESTIONS

- What's different about solar box cooking?

  COOKING TIME is about double but food won't burn or stick to the pan, so you don't need to stir.
  You can be gone for hours or all day, and food will finish cooking and stay delicious until you're ready to eat.
  Cooking outside helps keep heat out of the kitchen.

- WHERE?

  In most sunny parts of the world in a spot outdoors that stays sunny a few hours - even rooftops are sometimes used. In some communities communal solar cookers are guarded by one person.

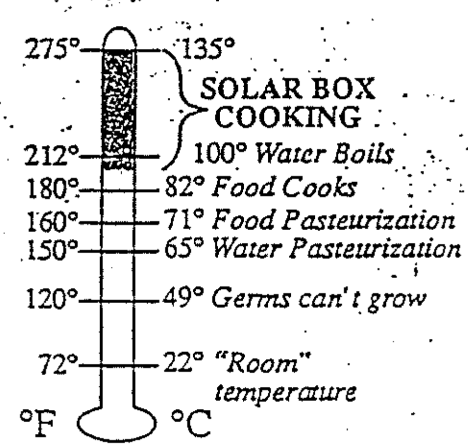


- WHEN?

  On days that are at least partly sunny. The cooker won't work well if you can't see clear shadows due to clouds or dust, or if your shadow is longer than you as in wintertime or early or late in the day.

- HOW HOT does a solar box get?

  Solar box cookers reach 95-135°C (200-275°F) - ideal for cooking food.
  People often assume hotter is better, but cookers that reach 300-400°F tend to dry out and burn foods so need watching.
  They also often require frequent moving to follow the sun.
  A note about temperatures: air temperature in an empty solar box is a poor measure of cooking capacity. Even with food in the cooker air temperature will vary alot in the sunny or shady part of the box. The cooker is designed to focus heat on the cooking pots. After 1-2 hours they will be hotter than the air temperatures.



- WILL FOODS SPOIL? In a solar box food quickly gets too hot for germs to grow, and disease organisms are killed BEFORE food gets hot enough to cook.
  As with any kind of cooking, foods may spoil if left for hours at room temperature, so don't leave food in a solar cooker overnight.

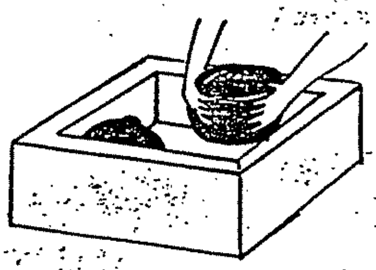
TO COOK FOOD IN A SOLAR BOX COOKER:

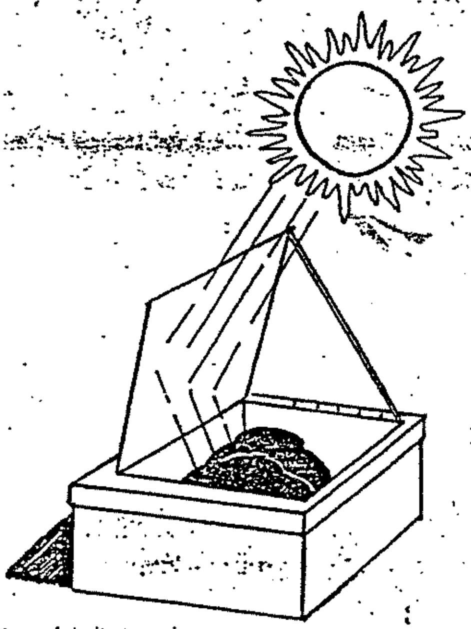
Start early. Food won't burn and rarely overcooks.

Put food into dark covered pots.

Add no water to fresh vegetables or meat.

You can cook separate meals for noon and evening, or just one meal all day. Either way food stays delicious until you are ready to eat.

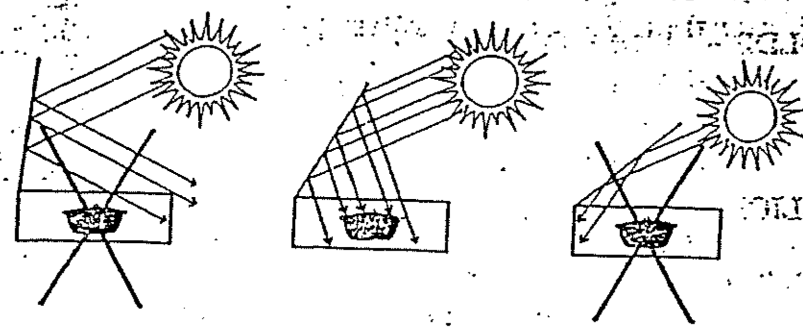




Place the solar box outside on a dry surface that will be sunny for several hours.

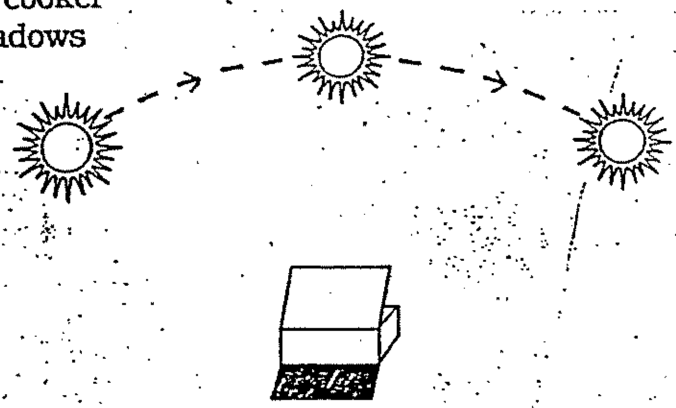
Put pots into the solar box and cover with the reflector lid. Place harder-to-cook foods and larger-quantity foods toward the back to get the most sun.

Aim the shiny reflector of the cooker toward the sun. Adjust it so the most extra sunlight shines into the box.

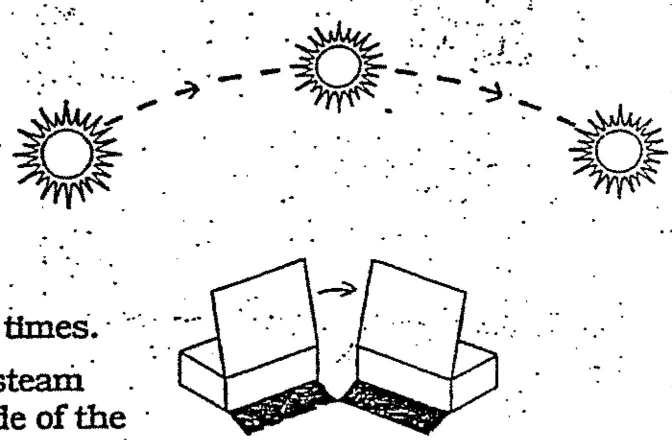


Food cooks a little faster if you turn the cooker once or twice during the day to keep shadows directly behind the cooker.

"Absentee" all-day cooking



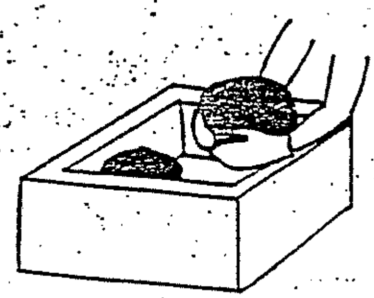
Cooking both noon and evening meals



No need to stir but it's OK to peek a few times.

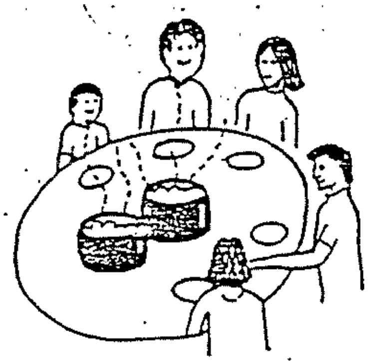
Water on glass: On windy or cold days steam from the food may condense on the inside of the window. Wipe occasionally with a clean cloth.

In case of sudden, brief showers put small rocks under the back of the cooker to tilt it a little so rain will run off. This also helps condensation inside to run off.



To keep food hot after sunlight is gone add a few stones or bricks. Food will heat and cook more slowly but will stay hot longer at the end of the day.

USE POT HOLDERS. POTS GET HOT!



ENJOY A DELICIOUS MEAL!

COOKING TIME ON A SUNNY DAY

EASY TO COOK
1-2 Hours


EGG


RICE


FRUIT

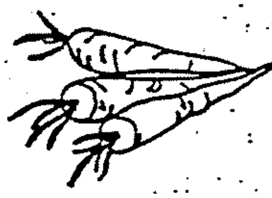

VEGETABLES (above ground)

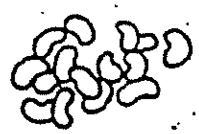

FISH


CHICKEN

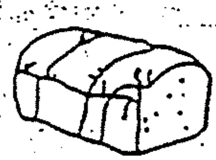
MEDIUM
3-4 Hours


POTATOES


VEGETABLES (roots)

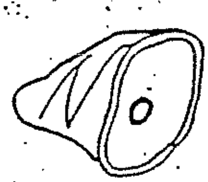

SOME BEANS, LENTILS


MOST MEAT


BREAD

HARD TO COOK
5-8 Hours


SOUP AND STEW


LARGE ROASTS
(all meats get more tender)

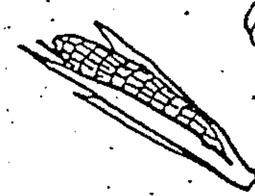

MOST DRIED BEANS

COOKING HINTS:

Cooking times are for 4-5 servings on a sunny day. See next page for variations.

COOKED CEREALS, GRAINS-barley, corn, millet, oats, quinoa, rice, wheat: Start with usual amount of water. Next time adjust to your taste. Heating water and dry cereal or grain separately before putting together may help to get the preferred texture.

VEGETABLES: - Add no water if fresh
Artichokes - 2 1/2 hours
Asparagus - 1 1/2 - 2 hours
Other green vegetables - 1 to 1 1/2 hours. If cooked longer they taste fine but lose their nice green color.
Beans (dried) - 3 to 5 hours. Add usual amount of water. Some cook faster if soaked several hours first.
Beets, carrots, potatoes, other root vegetables - 3 hours
Cabbage, eggplant - 1 1/2 hours if cut up
Eggplant turns brownish, like a cut fresh apple, but flavor is good.
Corn on the cob - 1 1/2 hours: Cook with or without inner husks. Try a clean black sock.
Squash, zucchini - 1 hour. They may turn mushy if left longer.

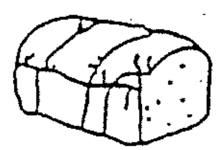


EGGS: Add no water to cook in shells - 2 hours for hard yolks. If cooked longer, whites may turn brownish, but flavor is good.

MEATS: Add no water. Longer cooking = more tender meat.
Fish - 1 to 2 hours
Chicken - 2 hours cut up, 3 hours whole
Beef, lamb, other red meats - 2 hours cut up, 3 to 5 hours for large pieces
Turkey, large and whole - all day

PASTAS: Heat water in one pot and dry pasta with a bit of cooking oil in another pot. Heat both until water is near boiling. Add hot pasta to hot water, stir, and cook about 10 minutes more..

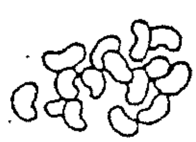
BAKING is best done in the middle of the day (between 9 AM and 3 PM).
Breads - 3 hours for whole loaves
Cakes - 1 1/2 hours, Cookies - 1 1/2 hours. Cookies don't need a cover.
Avoid bottom crusts in pastries - they get soggy.



WATER, MILK Pasteurization: 1 liter-1 hour, 1 gallon-4 hours

SAUCES/GRAVIES (made with flour or starch): Heat juices and flour separately, with or without a bit of cooking oil in the flour. Then combine and stir. It will be ready quickly.

ROASTING NUTS: Bake uncovered. Almonds - 1 hour, Peanuts (groundnuts) - 2 hours



Please send us YOUR favorite recipes.

Twelve cooking speed factors:

WEATHER

Seasons and time of day (length of shadows)

Clouds or dust

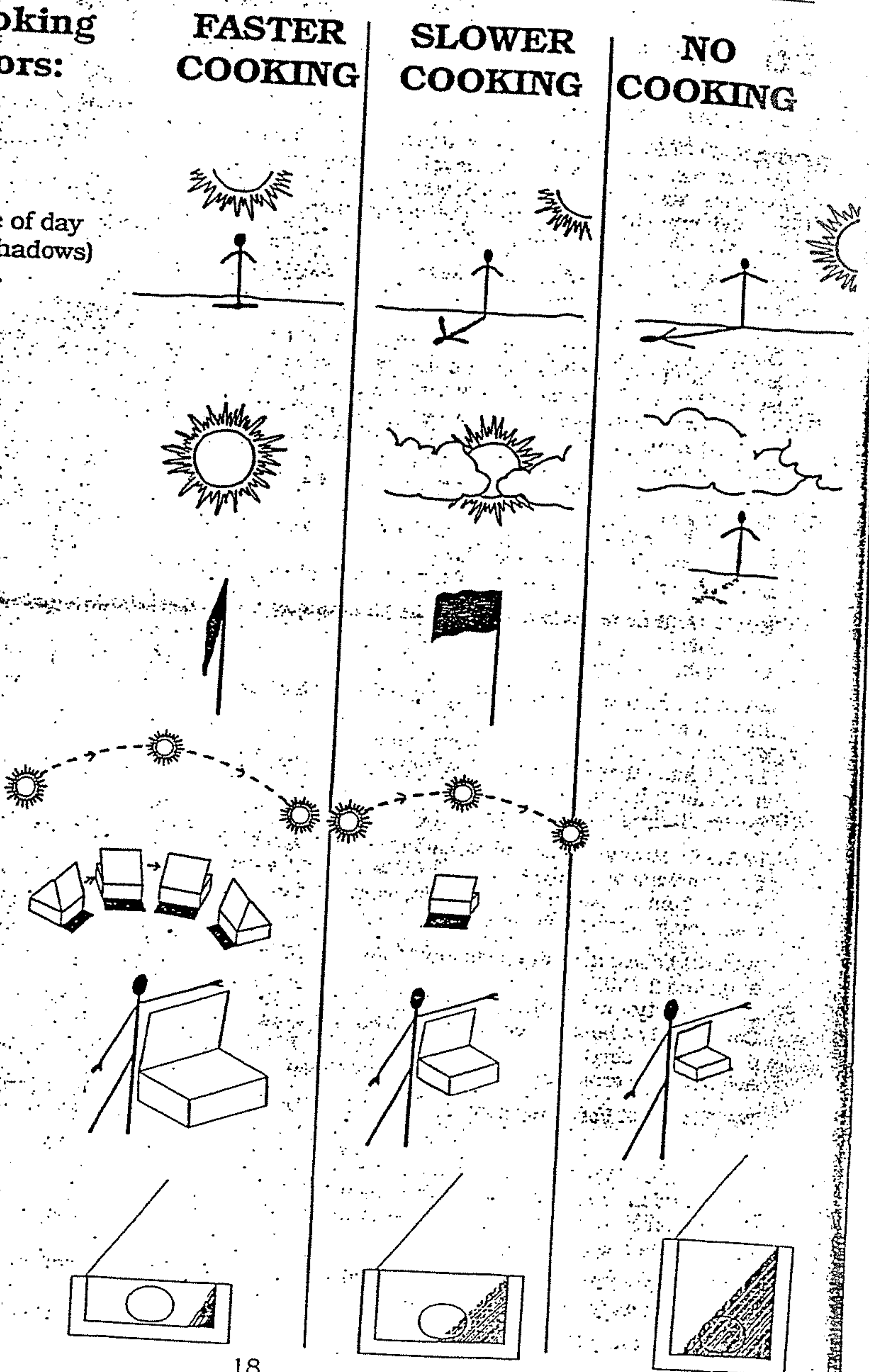
Wind

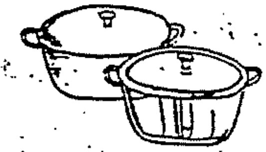
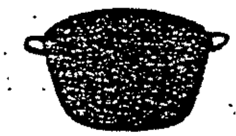
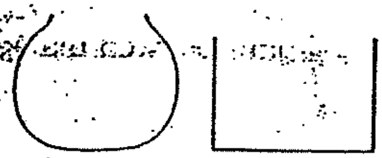
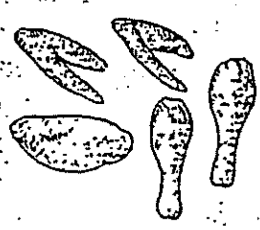
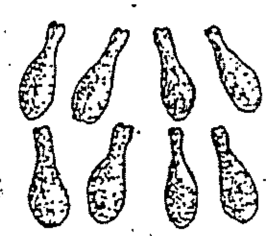
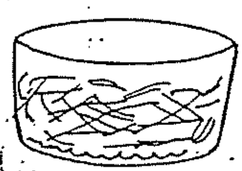
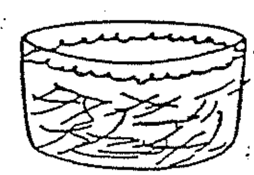
THE BOX

Turning cooker to sun 1-2 times

Cooker size

Cooker depth



	FASTER COOKING	SLOWER COOKING
POTS		
Color of pots		
Size of pots		
Pots material, thickness		
FOOD		
Food piece size		
Food quantity		
Water content		

OTHER USES

- **For emergencies and disaster relief**

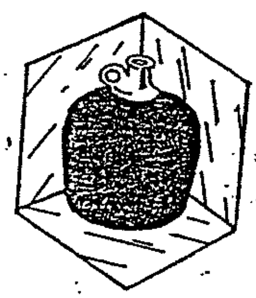
Solar box cookers can save lives when electricity, gas, wood and/or safe water supplies are disrupted.

- **Water pasteurization**

To kill disease organisms in water, heat in a solar box to 65°C (150°F). Note: water does not need to boil, but when you see the water boiling (100°C, 212°F) you know for sure it is safe from germs.

Pasteurizing doesn't make water safe from harmful chemicals such as pesticides or industrial wastes.

On a good sunny day, 4 liters (1 gallon) of water can be pasteurized in about four hours. Glass jars painted black on the outside work well. Plastic ones may melt at high temperatures. Fill jars almost to the top and cover LOOSELY. After pasteurizing, tighten lid to help to keep water clean.



Note: Another way to heat water for washing or other uses is with a simple 3-sided reflector made of cardboard and foil. This won't get hot enough to pasteurize the water, but can preheat it for quicker finishing in the solar box.

- **Disinfecting medical equipment and bandages.**

In difficult field conditions where there is no pressure sterilization (autoclaving), a solar box can destroy most germs. Heat medical instruments in water to boiling. Items that must stay dry need to reach 149° (300°F), possible with larger solar boxes.

A few germs survive "pasteurizing" and are harmful if they get into an open wound. These require very high temperatures under pressure ("autoclaving") to destroy.

- **Preserving ("canning") foods**

Fruits can be preserved ("canned") for long-term storage just like "open-kettle" canning on a stove. Fill jars to top with fruit and juice and cover loosely. Heat until juices start to bubble over, tighten lids, then cook

- **Together with another cooking method:**

- For faster solar cooking on sunny days bring pot(s) of food to boiling on another stove before putting into the solar box.

- To stretch fuel on cloudy days bring cooker inside. Put boiling pot(s) in the solar box and surround pot(s) with hay or pillows. Food continues cooking on stored heat.

- On a partly sunny day the reverse also works: If food comes to boil in a solar box when the weather turns cloudy or rainy, bring the solar box inside, pack pillows inside around the pots to continue cooking.

- **Drying foods**

If a more effective solar food dryer isn't available, place a tray of food ON TOP of the wondow of the solar box lid in front of the reflector, and/or inside the cooker with the lid off. The extra glare of the shiny foil helps keep insects away.

- **Bugs in the pantry?**

To get rid of insect larvae or beetles in dry food staples, preheat a solar box about 10 minutes. Spread food on a tray inside the cooker and heat for about 20 minutes, stirring once about half way through.

- **Commercial uses:**

Boiling rice straw to make paper

In fabrics industries to dye wool, kill silk larvae

Heating hot dogs for beach vendors

Baking bread for a communal business

A small business project to build and sell cookers.

- **And other:**

Pasteurizing potting soil

Heating stones for bedwarming